PHASES OF THE SEA-BREEZE IN THE ISLAND OF MALLORCA

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1) THE SEA-BREEZE (SB) IN THE ISLAND OF MALLORCA

✓The SB is a locally-generated wind from sea to land direction due to the thermal difference between land-sea (Figure 1). During a SB event a maximum of wind (4-6 m/s) is generated at lower levels (about 250m agl) between 1200-1500 UTC (Ramis and Romero, 1995; Cuxart et al., 2014).

✓**OBJECTIVE**: to further understand the initiation of the SB in Mallorca, as an example of a complex terrain island, with the combined inspection of observations and high-resolution mesoscale modelling. Work in progress, preliminary results in Jiménez et al. (2015).

✓**MALLORCA SEA BREEZE (MSB)** EXPERIMENTAL FIELD CAMPAIGN in the Campos basin (at the south). The main site was in Ses Covetes (Figure 2), 1km from the seashore. Observations at the surface (T, RH, wind and turbulence) and at the lower atmosphere (up to 300m agl, captive balloon and multicopter).

✓Due to the strength of the SB wind, the campaigns were conducted at the beginning and the end of the summer: **MSB13**: 12 – 20 September 2013 (1 IOP) and **MSB14**: 26 May – 6 June 2014, (5 IOPs).

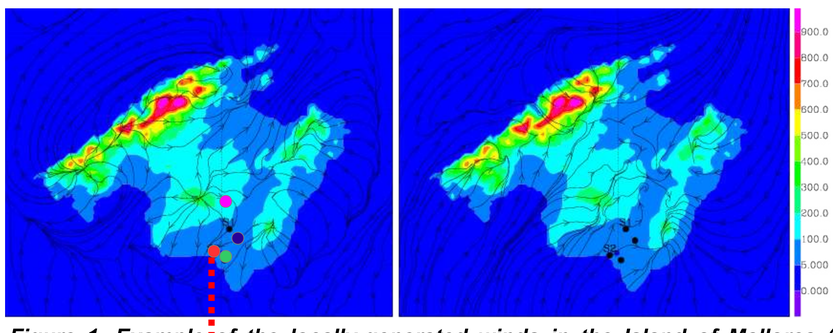

Figure 1. Example of the locally-generated winds in the Island of Mallorca (Western Mediterranean Sea) on 20th September 2013 seen by the MesoNH model (Lafore et al., 1998) at 1km horizontal resolution: (LEFT) land-breeze (0400 UTC) and (RIGHT) sea-breeze (1100 UTC). The coloured points indicate the location of the observations (AEMET) and in red the MSB13 and MSB14 site (Ses Covetes).

Figure 2. Location of Ses Covetes together with different sensors installed in this site.

2) MSB13

✓ The observed SB initiation of the SB during 20th September 2013 is further investigated. After sunrise, temperature and wind speed progressively increase meanwhile the wind turns towards the SB direction (about 240º). Once the turning is completed (0900 UTC) the temperature and wind direction remain constant. Model results agree with observations (Figure 3 and 7).

✓ The tethered balloon observations have a warm bias related to the sun heating of the sensor and the small-scale processes close to the surface (between 0700-0800 UTC, Figure 4) are not well reproduced. However, a similar behaviour is found in the observed thermal vertical structure (multicopter and balloon) and the model (Figure 5).

✓ A summary of the SB phases is shown in the Table.

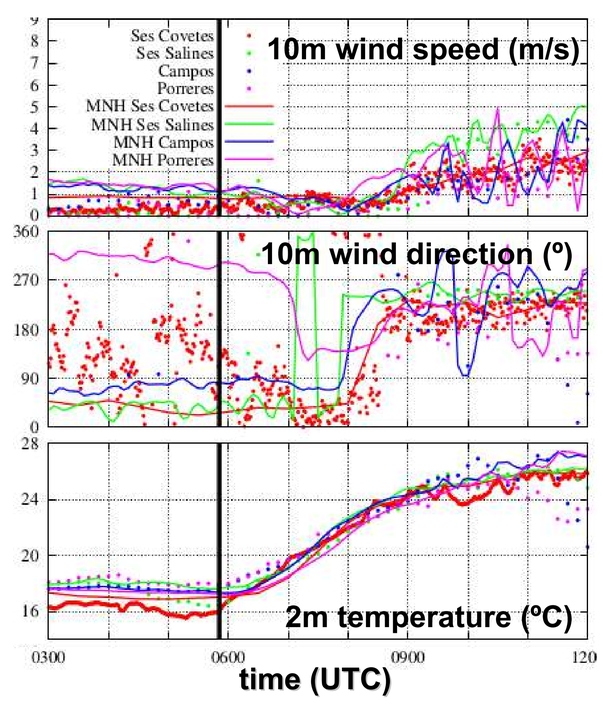

Figure 3. Temporal evolution of the wind and temperature observed from the surface weather stations (in dots, see Figure 1) together with the modelled results (in lines). Sunrise is indicated with a black vertical line.

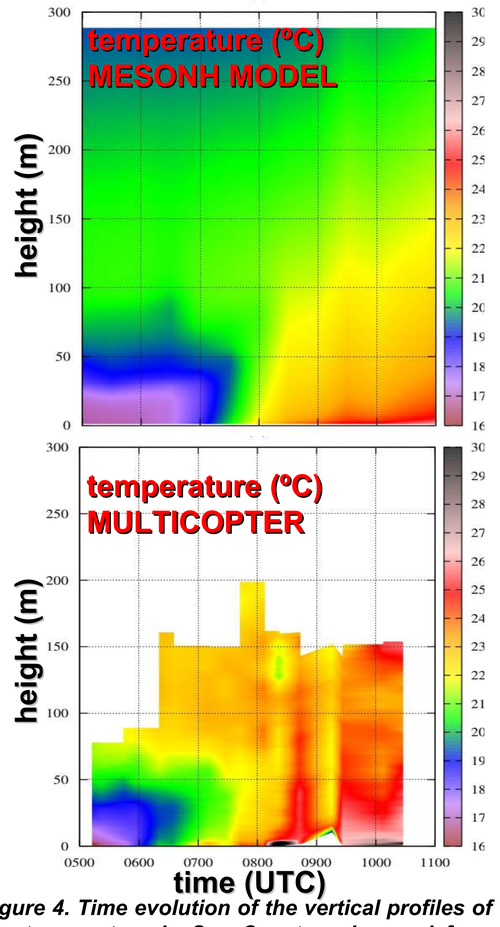

Figure 4. Time evolution of the vertical profiles of the temperature in Ses Covetes observed from the multicopter and obtained from the model.

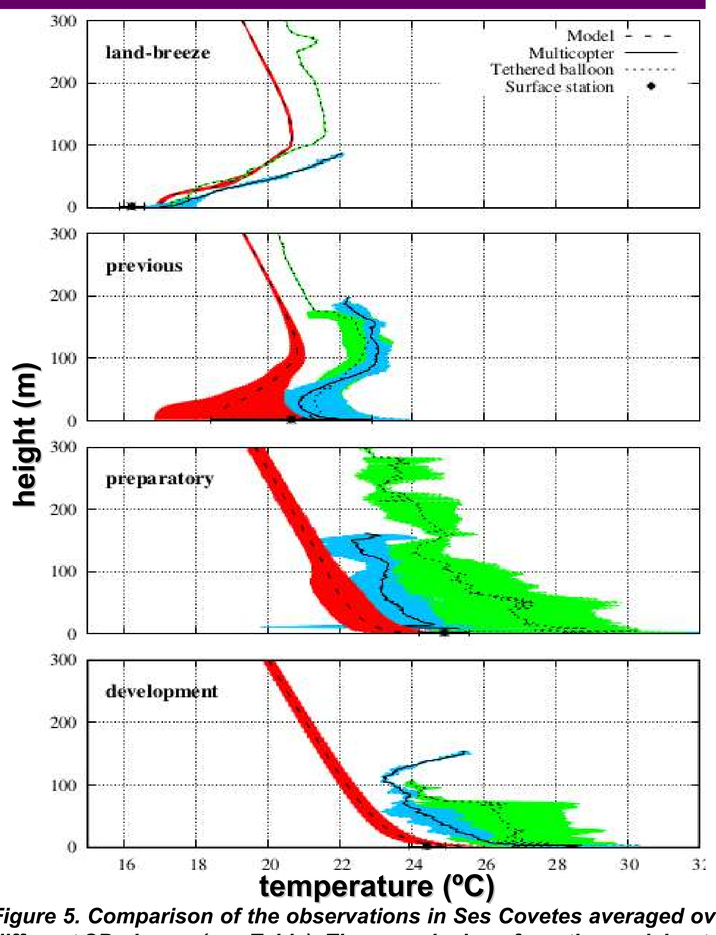

Figure 5. Comparison of the observations in Ses Covetes averaged over the different SB phases (see Table). The same is done from the model outputs.

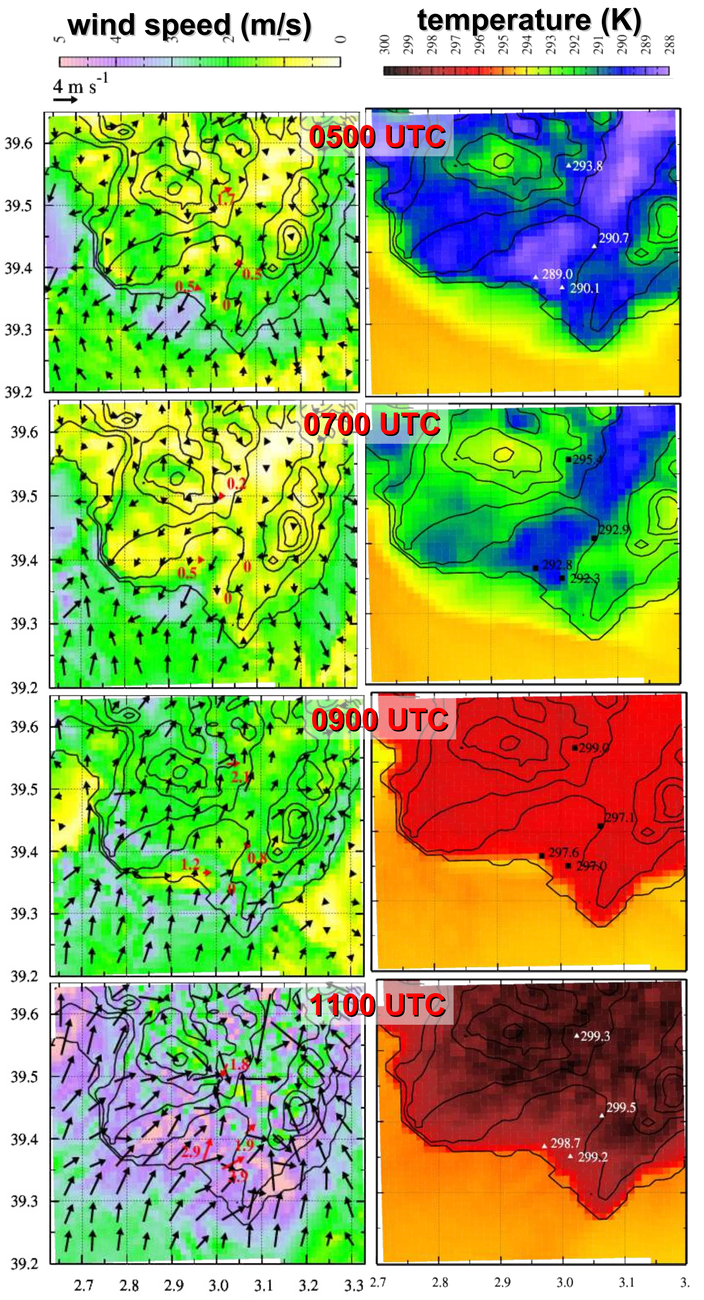

Figure 6. Modelled wind fields at 50m (agl) and 1.5m temperature at different hours during the initiation of the SB in the Campos basin. Observations are also included with a number and in lines there is the topography.

3) MSB14

✓ **4 IOPs in MSB14 cover the establishment of the SB.** In comparison to MSB13, turbulence measurements were performed.

✓ The analysis of the MSB14 IOPs is a **work in progress** but preliminary results show that **the main patterns found in MSB13 are also observed in MSB14.**

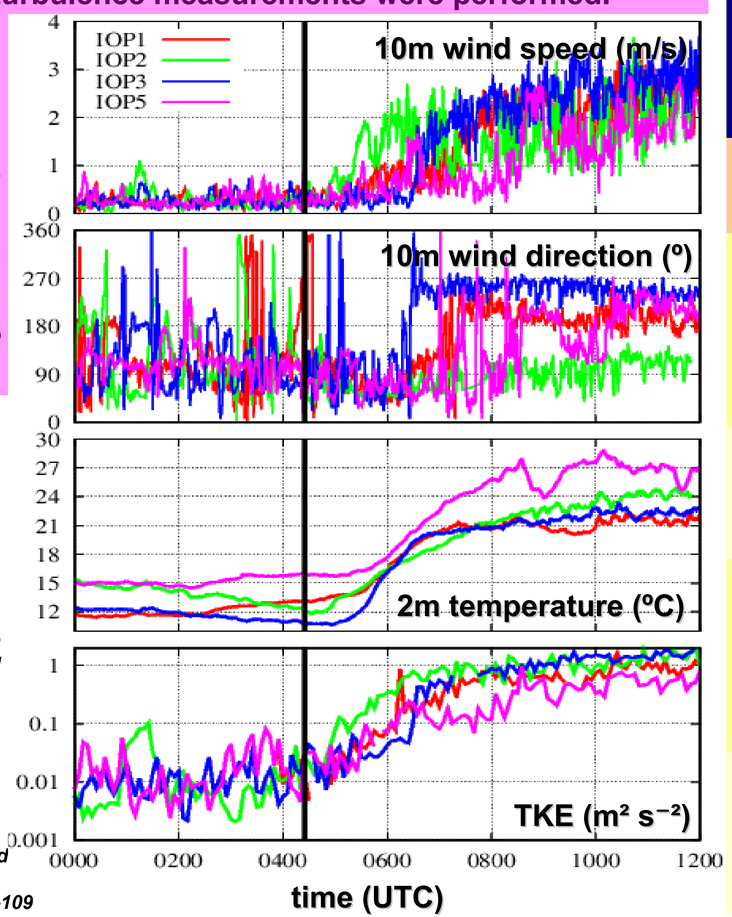

Figure 7. Temporal evolution of the wind, temperature and TKE observed during MSB14 in Ses Covetes.

Cuxart et al. (2014): JAMC, 53, 2589-2609
Cuxart et al. (2007): MWR, 135, 918-932
Jiménez et al. (2015): MAP, to be submitted
Ramis, Romero (1995): AG, 13, 981-994
Lafore et al. (1998): Ann. Geophys., 16, 90-109

4) SUMMARY

✓With the combined analysis of the observations from experimental field campaigns (MSB13 & MSB14) and high-resolution mesoscale simulations it is possible to identify 4 phases during the establishment of the SB.

✓Mallorca is a complex terrain island and the initiation of the SB is also affected by the upslope (day) and downslope (night) winds ofbthe mountain slopes.

PHASE	INTERVAL (UTC)	FEATURES
LAND-BREEZE	0400-0600 *sunrise: 0600 UTC	* **coast**: land-breeze (wind from land to sea) * **slopes**: downslope winds * SST >> LST * cold air advected towards the warm sea
PREVIOUS	0600-0800	* **coast**: land-breeze still present * **slopes**: downslope winds are less intense * SST>LST
PREPARATORY	0800-1000	* **coast**: weak wind but with sea-breeze direction * **slopes**: upslope winds * LST homogeneous in the center of the basin but about 1-2 K warmer than SST
DEVELOPMENT	1000-1200	* **coast**: SB increases intensity. SB front propagates through the basin * **slopes**: upslope winds increase intensity * SST<LST